

Search for MSSM Higgs Decaying to Taus



Dongwook Jang

Rutgers University

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Motivation



- ➔ Minimal Supersymmetric extension of Standard Model (MSSM) predicts five Higgs bosons

h^0/H^0 (CP-even), A^0 (CP-odd), H^\pm

- ➔ MSSM parameters related with higgs : $\tan\beta = 30$, $m_A = 120, 140, 160$ GeV

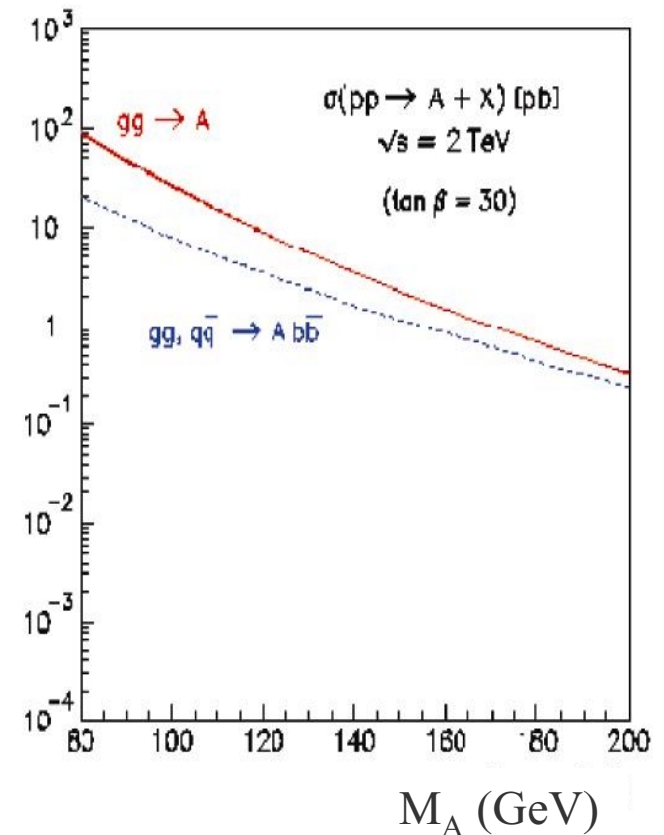
- ➔ Higgs production at the Tevatron

$b\bar{b} \rightarrow \phi$ ($= h/H/A$), $gg \rightarrow \phi$, $q\bar{q} \rightarrow \phi$, etc.

- ➔ Higgs decay modes :

$\phi \rightarrow b\bar{b}$, $\phi \rightarrow \tau\tau$, etc.

(pb)



Motivation cont'd

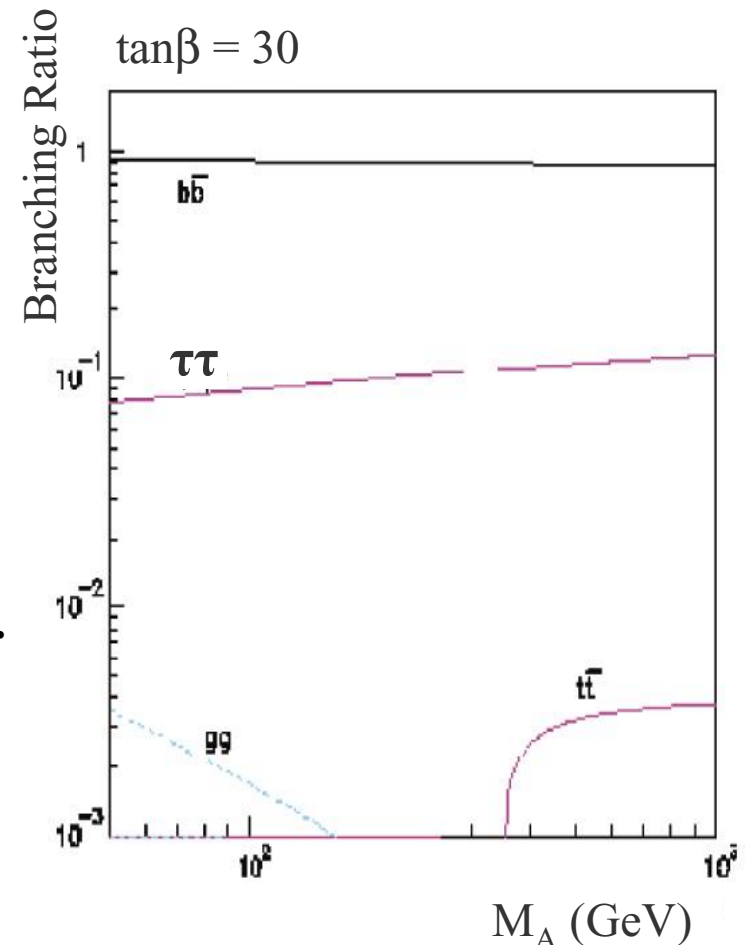


Why is τ channel interesting?

- Second largest branching fraction after $\phi \rightarrow b\bar{b}$
- $\phi \rightarrow b\bar{b}$ dominated by fakes.
- **Much cleaner** than $\phi \rightarrow b\bar{b}$ although $\phi \rightarrow \tau\tau$ branching fraction is ~ 10 times smaller.

τ decay properties

- Rich decay spectrum.
- $\tau \rightarrow e\nu_e\nu_\tau, \tau \rightarrow \mu\nu_\mu\nu_\tau$: leptonic decays ($\sim 36\%$).
- $\tau \rightarrow \pi\nu_\tau, \tau \rightarrow \pi\pi^0\nu_\tau, \tau \rightarrow \pi\pi\pi\nu_\tau$: hadronic decays ($\sim 64\%$).
- Always accompanied by **missing energy** due to neutrinos in final state.



Data and MC Description



➤ Data

- $e + \tau$ trigger : $\sim 72 \text{ pb}^{-1}$
- Jet trigger (for fake rate studies) : $\sim 72 \text{ pb}^{-1}$

➤ Signal MC

- Generated by Pythia with $\tan\beta = 30$, $M_A = 120, 140, 160 \text{ (GeV)}$.
- Used (τ_e, τ_h) final states, where τ_e denotes $\tau \rightarrow e \nu_e \nu_\tau$
and τ_h denotes hadronically decaying τ

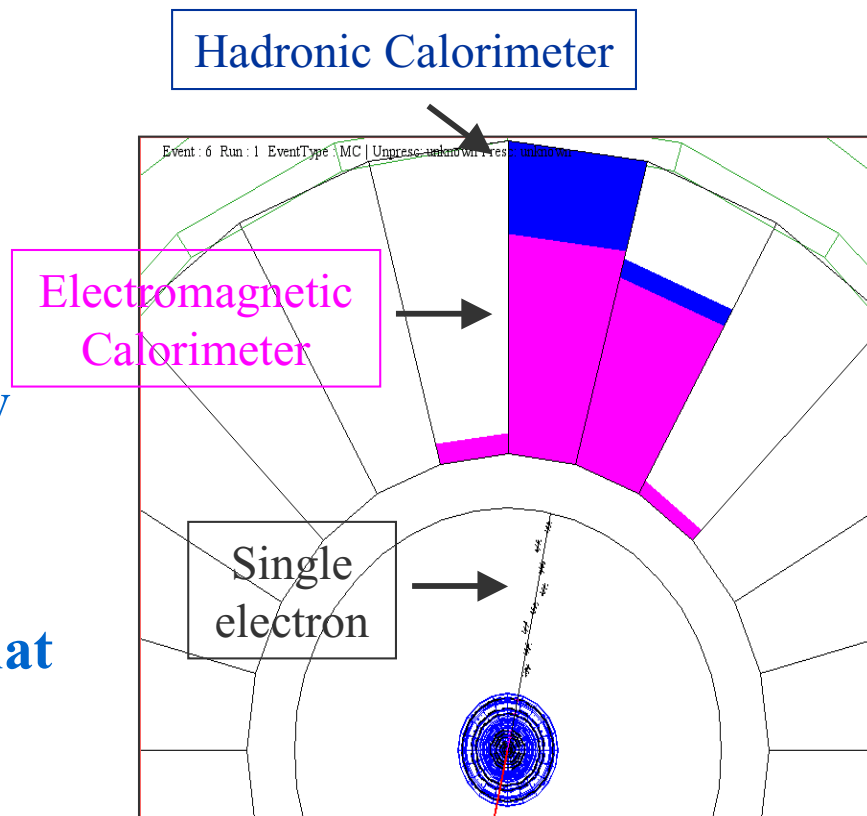
➤ Backgrounds

- $Z/\gamma^* \rightarrow \tau \tau$ (irreducible background) generated by Pythia.
- $Z/\gamma^* \rightarrow e e$ generated by Pythia.
- $W \rightarrow e \nu_e + \text{jets}$ generated by Alpgen+Herwig.

Electron Identification



- **Isolated track.**
- **Deposits most of its energy in EM calorimeter.**
- **Signature in ShowerMax detector consistent with that expected for an electron.**



Identification of hadronically decaying τ

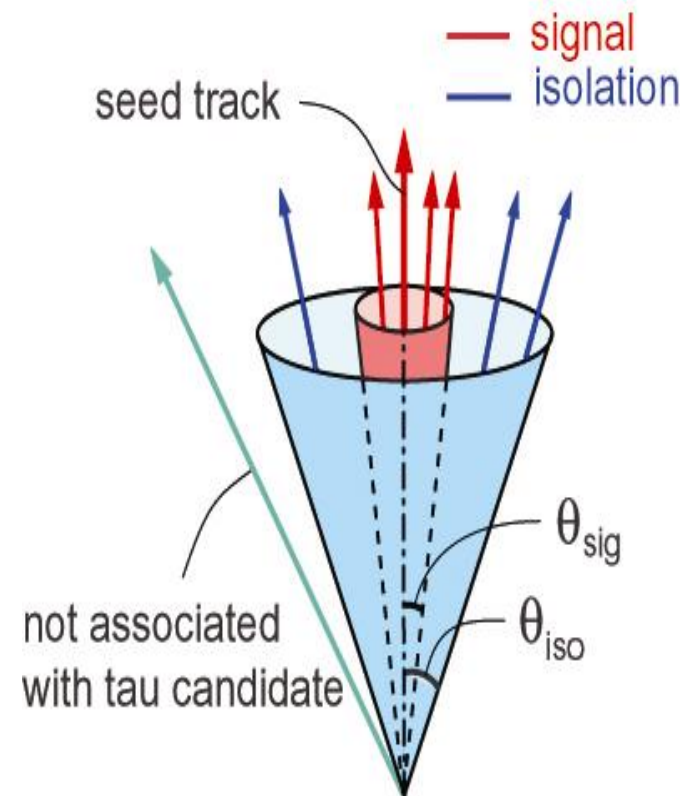


Expected signature:

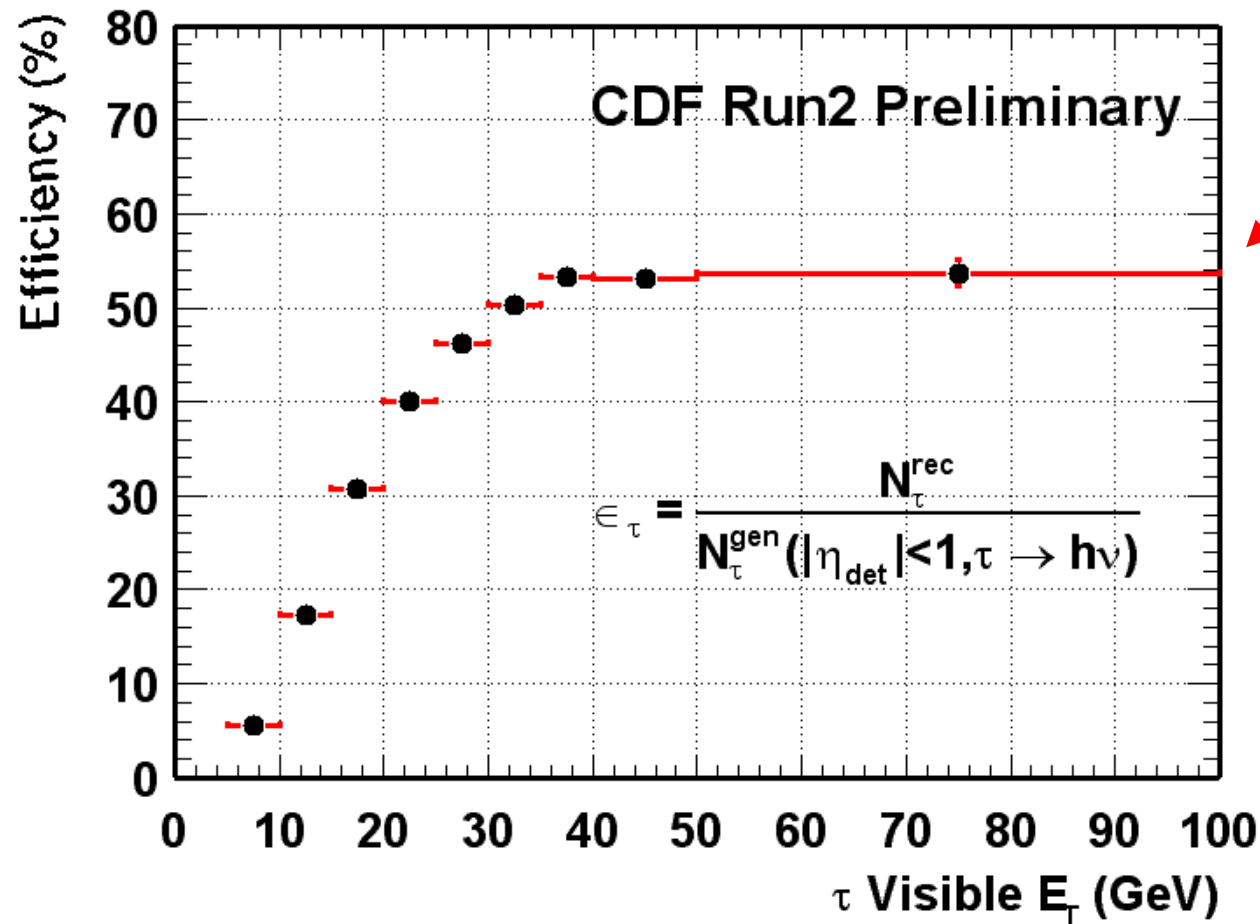
- Narrow, isolated jet.
- Low track multiplicity (1 or 3).
- Low π^0 multiplicity (0-3).

Reconstruction framework:

- Define signal and isolation cones.
- Require number of tracks and π^0 s in signal cone to be consistent with expected signature; $M < 1.8$ GeV.
- No tracks and π^0 s between signal and isolation cone.



Identification of hadronically decaying τ cont'd

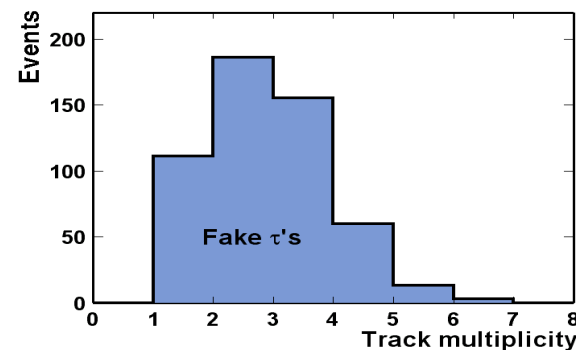
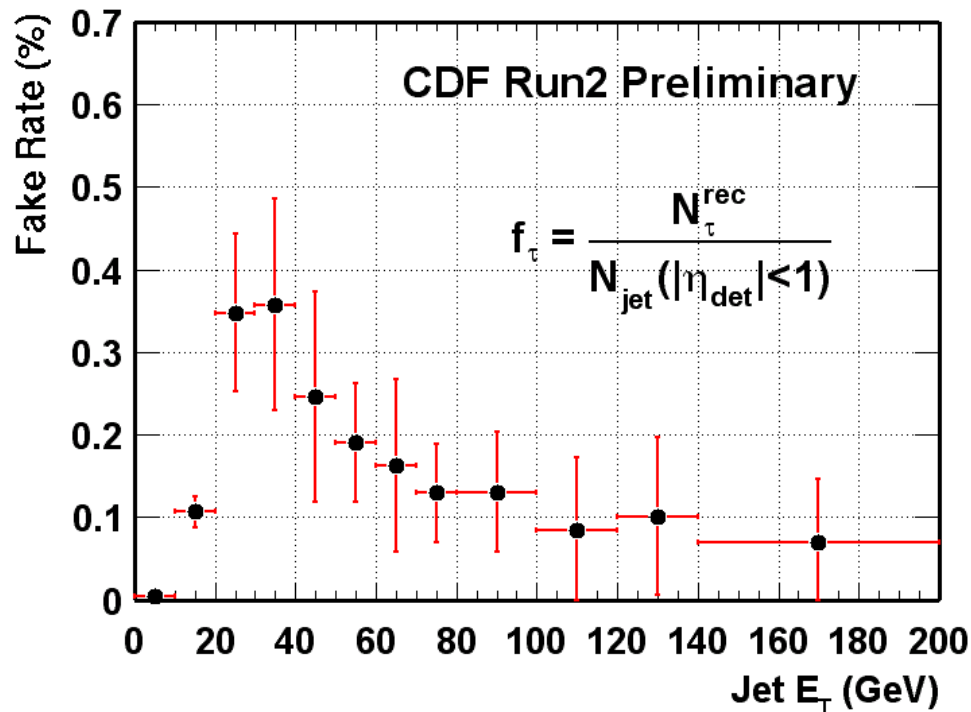


Identification of hadronically decaying τ cont'd



➡ Jet \rightarrow τ fakes

- Studied using unbiased jet sample from the data.
- Fake rate < 0.4%, about a factor of 3 improvement over CDF Run 1 !!!
- Create templates for use in analysis.



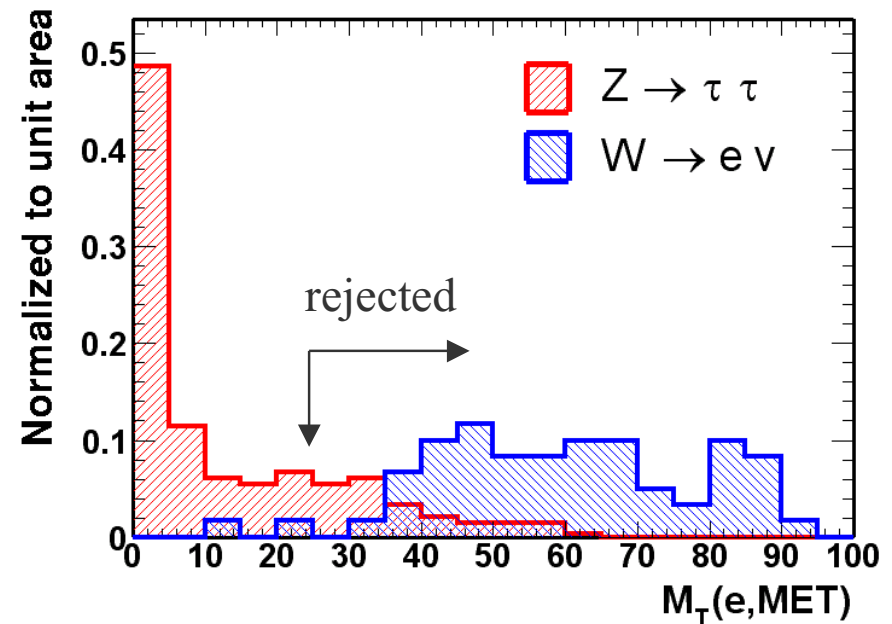
Backgrounds



- **Dijet** : mostly suppressed by e, τ identification
- **$Z \rightarrow e e$** : Remove events with M_{ee} near M_Z

- **$W \rightarrow e \nu + \text{jets}$**

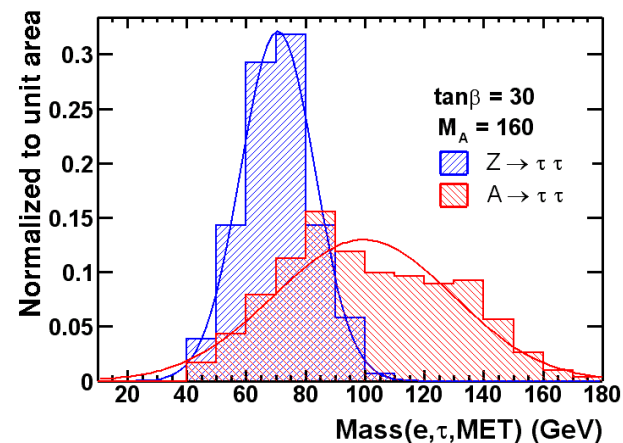
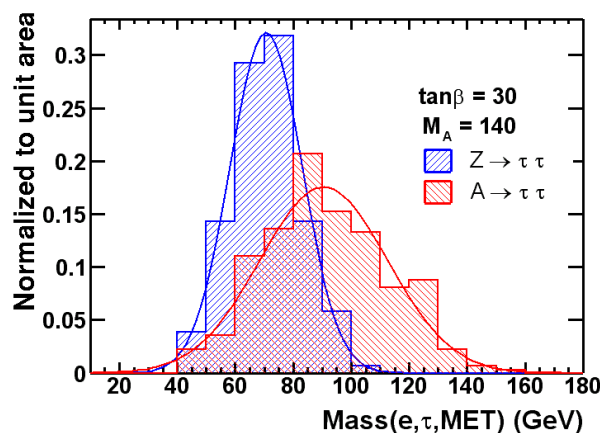
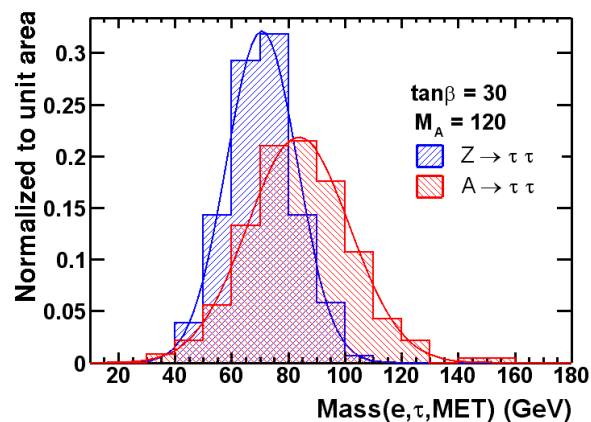
- One jet misidentified as τ
- Cut on e, \cancel{E}_T transverse mass effectively eliminates this background.



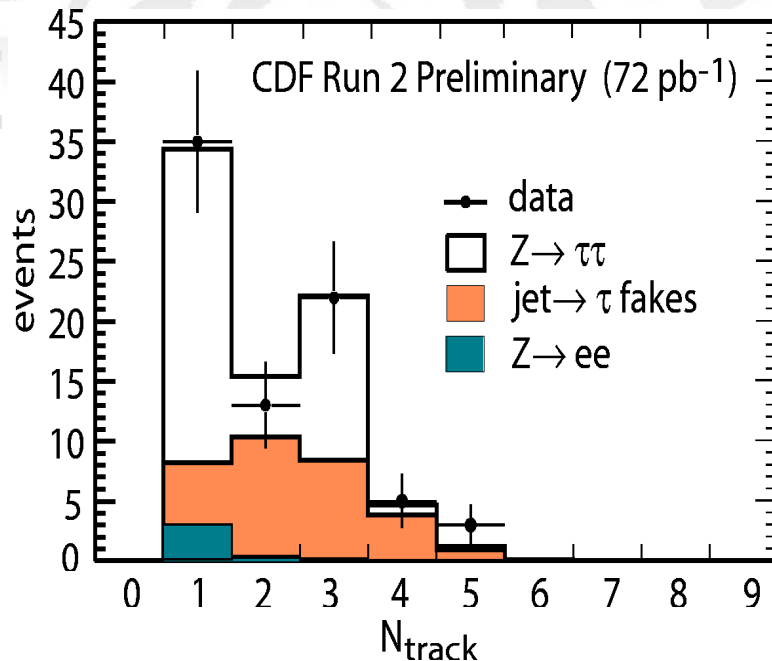
Irreducible background: $Z \rightarrow \tau\tau$



- Same final state as $\phi \rightarrow \tau\tau$
- Can be discriminated by invariant mass, $M_{\tau\tau}$
- Form \vec{E}_T four vector ignoring z component and take invariant mass of $\tau_e, \tau_h, \vec{E}_T$
- Before performing $\phi \rightarrow \tau\tau$ search, we must see $Z \rightarrow \tau\tau$ signature first (not previously observed by CDF)



Tau Signature



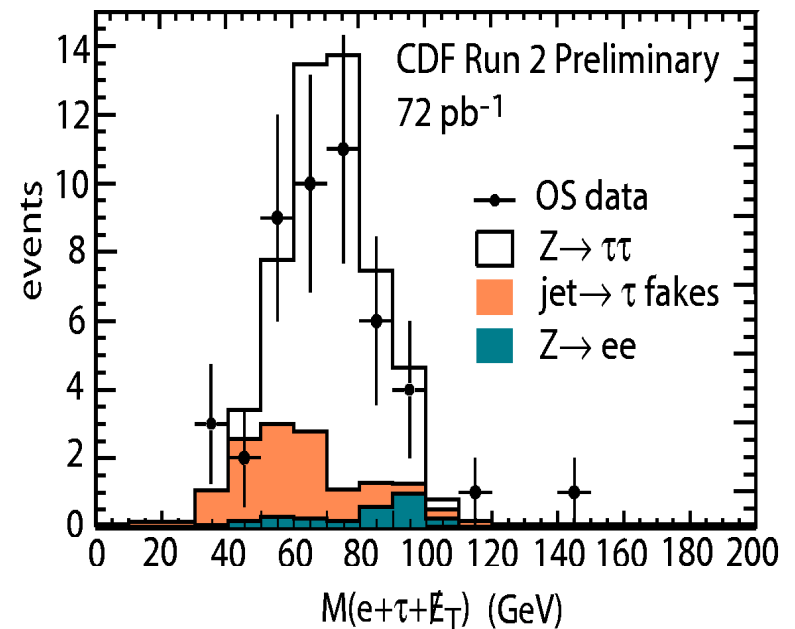
● Fit with templates from **jet $\rightarrow \tau$ fakes**, $Z \rightarrow \tau\tau$, $Z \rightarrow ee$ (fixed)

● Fit results

► $N_{Z \rightarrow \tau\tau} = 46 \pm 15$ (fit result)

► $N_{Z \rightarrow \tau\tau} = 43$ (theory)

Mass distribution of opposite sign (τ_e, τ_h)



Summary and Plan



- Analysis tools are ready !
- **Observed** $Z \rightarrow \tau\tau$ final state, with (τ_e, τ_h) .
- **Work on** (τ_μ, τ_h) , (τ_h, τ_h) final states in progress.
- **Better mass reconstruction Techniques** being developed.